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Gaia Early Data Release 3

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Gaia Early Data Release 3

Summary of the contents and survey properties

(Corrigendum)

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This is a corrigendum for Gaia Collaboration (2021). It corrects errors in Sects. 6.3.2 and 7.2 and Appendix A, which erroneously state that the correction to the G-band fluxes and magnitudes presented in Riello et al. (2021) (their Table 5) should be applied to sources in *Gaia* EDR3 with six-parameter astrometric solutions. In fact, the corrections should be applied to sources with two-parameter or six-parameter astrometric solutions. The corrected Astronomical Data Query Language (ADQL) query and Python source code from Appendix A are presented in the new version of Appendix A below.

Following the discovery of the above error, a more detailed investigation was done for the sources with two-parameter (2-p) astrometric solutions. Out of the 344 million 2-p sources present in *Gaia* EDR3, about 20 million have an astrometric solution in which the actual source colour was used instead of a default colour. This means that for these 20 million 2-p sources the G-band correction should actually not be applied. These sources are mostly faint, with 96% at magnitudes $G > 20$, and for 75% of these 20 million sources the correction that is (wrongly) applied amounts to less than 4 milli-magnitudes. It was thus decided not to make a special effort to exclude these sources from the correction. Should a user of the *Gaia* EDR3 data wish to undo the wrong correction for one or more of these 20 million sources, the list of source IDs and applied corrections can be provided on request.

Appendix A: *G*-band corrections for sources with two-parameter or six-parameter astrometric solutions

Figure A.1 shows how to formulate an ADQL query, to be executed in the *Gaia* EDR3 archive, that contains an on-the-fly calculation of the corrected G-band fluxes or magnitudes. These queries are somewhat complex and create a performance overhead. Hence downloading the requisite *Gaia* EDR3 fields and calculating the corrections a posteriori may be more efficient. Example Python code to do this is included in Fig. A.2. The Python code is also available as a Jupyter notebook[1].

[1] https://github.com/agabrown/gaiaedr3-6p-gband-correction

Query that includes a calculation of the G-band flux correction. The condition '`bp_rp > -20`' ensures that no correction is attempted in case the $(G_{BP} - G_{RP})$ colour is not available ('`bp_rp is not null`' does not work). The condition on `random_index` is included to retrieve example data for a random sample of sources.

```
select source_id, astrometric_params_solved, bp_rp, phot_g_mean_mag, phot_g_mean_flux,
if_then_else(
  bp_rp > -20,
  case_condition(
    phot_g_mean_flux * (1.00525 -0.02323*greatest(0.25, least(bp_rp, 3))
            +0.01740*power(greatest(0.25, least(bp_rp, 3)),2)
            -0.00253*power(greatest(0.25, least(bp_rp, 3)),3)),
    astrometric_params_solved = 31,
    phot_g_mean_flux,
    phot_g_mean_mag < 13,
    phot_g_mean_flux,
    phot_g_mean_mag < 16,
    phot_g_mean_flux * (1.00876 -0.02540*greatest(0.25, least(bp_rp, 3))
                    +0.01747*power(greatest(0.25, least(bp_rp, 3)),2)
                    -0.00277*power(greatest(0.25, least(bp_rp, 3)),3))
  ),
  phot_g_mean_flux
) as phot_g_mean_flux_corr
from gaiaedr3.gaia_source
where random_index between 1000000 and 1999999
```

Query that includes a calculation of the G-band magnitude correction. We note the type-cast '`to_real()`' of the return value of the conditional part of the query.

```
select source_id, astrometric_params_solved, bp_rp, phot_g_mean_mag, phot_g_mean_flux,
if_then_else(
  bp_rp > -20,
  to_real(case_condition(
    phot_g_mean_mag - 2.5*log10( (1.00525 -0.02323*greatest(0.25, least(bp_rp, 3))
                                +0.01740*power(greatest(0.25, least(bp_rp, 3)),2)
                                -0.00253*power(greatest(0.25, least(bp_rp, 3)),3)) ),
    astrometric_params_solved = 31,
    phot_g_mean_mag,
    phot_g_mean_mag < 13,
    phot_g_mean_mag,
    phot_g_mean_mag < 16,
    phot_g_mean_mag - 2.5*log10( (1.00876 -0.02540*greatest(0.25, least(bp_rp, 3))
                                +0.01747*power(greatest(0.25, least(bp_rp, 3)),2)
                                -0.00277*power(greatest(0.25, least(bp_rp, 3)),3)) )
  )),
  phot_g_mean_mag
) as phot_g_mean_mag_corr
from gaiaedr3.gaia_source
where random_index between 5000000 and 5999999
```

Fig. A.1. Example queries that can be submitted to the *Gaia* archive in ADQL to retrieve corrected G-band photometry.

```python
import numpy as np

def correct_gband(bp_rp, astrometric_params_solved, phot_g_mean_mag, phot_g_mean_flux):
    """
    Correct the G-band fluxes and magnitudes for the input list of Gaia EDR3 data.

    Parameters
    ----------

    bp_rp: float, array_like
        The (BP-RP) colour listed in the Gaia EDR3 archive.
    astrometric_params_solved: int, array_like
        The astrometric solution type listed in the Gaia EDR3 archive.
    phot_g_mean_mag: float, array_like
        The G-band magnitude as listed in the Gaia EDR3 archive.
    phot_g_mean_flux: float, array_like
        The G-band flux as listed in the Gaia EDR3 archive.

    Returns
    -------

    The corrected G-band magnitudes and fluxes. The corrections are only applied to
    sources with a 2-parameter or 6-parameter astrometric solution fainter than G=13,
    for which a (BP-RP) colour is available.

    Example

    gmag_corr, gflux_corr = correct_gband(bp_rp, astrometric_params_solved,
                                          phot_g_mean_mag, phot_g_mean_flux)
    """
    if np.isscalar(bp_rp) or np.isscalar(astrometric_params_solved) or \
                    np.isscalar(phot_g_mean_mag) or np.isscalar(phot_g_mean_flux):
        bp_rp = np.float64(bp_rp)
        astrometric_params_solved = np.int64(astrometric_params_solved)
        phot_g_mean_mag = np.float64(phot_g_mean_mag)
        phot_g_mean_flux = np.float64(phot_g_mean_flux)

    if not (bp_rp.shape == astrometric_params_solved.shape \
                    == phot_g_mean_mag.shape == phot_g_mean_flux.shape):
        raise ValueError('Function parameters must be of the same shape!')

    do_not_correct = np.isnan(bp_rp) | (phot_g_mean_mag<13) | \
                                  (astrometric_params_solved == 31)
    bright_correct = np.logical_not(do_not_correct) & (phot_g_mean_mag>=13) & \
                              (phot_g_mean_mag<=16)
    faint_correct = np.logical_not(do_not_correct) & (phot_g_mean_mag>16)
    bp_rp_c = np.clip(bp_rp, 0.25, 3.0)

    correction_factor = np.ones_like(phot_g_mean_mag)
    correction_factor[faint_correct] = 1.00525 - 0.02323*bp_rp_c[faint_correct] + \
        0.01740*np.power(bp_rp_c[faint_correct],2) - \
        0.00253*np.power(bp_rp_c[faint_correct],3)
    correction_factor[bright_correct] = 1.00876 - 0.02540*bp_rp_c[bright_correct] + \
        0.01747*np.power(bp_rp_c[bright_correct],2) - \
        0.00277*np.power(bp_rp_c[bright_correct],3)

    gmag_corrected = phot_g_mean_mag - 2.5*np.log10(correction_factor)
    gflux_corrected = phot_g_mean_flux * correction_factor

    return gmag_corrected, gflux_corrected
```

Fig. A.2. Python code for calculating the corrections to the G-band photometry for sources with two-parameter or six-parameter astrometric solutions.

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Riello, M., De Angeli, F., Evans, D. W., et al. 2021, A&A, 649, A3

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